SUSTAINABLE DEVELOPMENT OF PERI-URBAN AGRICULTURE IN SOUTH-EAST ASIA
Kingdom of Cambodia, Lao PDR, Vietnam RS

SUSPER

AQUACULTURE SYSTEMS IN HCM CITY

Le Thanh Hung - HCM University of Agriculture and Forestry
April 2003

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RIFAV - Vien Rau Qua - Trau Quy, Gia Lam, Hanoi, Vietnam Tel: +844 8 768287

Sustainable Development of Peri-urban in South-east Asia (Susper)

(Kingdom of Cambodia, Lao PDR, Vietnam RS)

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I. COMPONENT I- ANALYSIS OF PERIURBAN PRODUCTION

This component contains two sub-sections that have been implemented in HCM City: Analyzing periurban aquaculture systems and modeling periurban agriculture production systems.

1. AQUACULTURE SYSTEMS IN HCM CITY

The water surfaces in the periurban area are vast. This potential has not been exploited however, since only 5,500 ha to 6,000 ha have been used for aquaculture to date as follows:

Freshwater fish culture: 1,000 – 1,200 ha

Brackish water fish culture: 3,000 – 3,500 ha

Shellfish production in brackish shallow water: 1,500 – 2,000 ha

Variations in the water surface/aquaculture production ratio since 1990 are represented in the table below.

Table 1: Variations in periurban aquaculture area and production in HCM City

Year	Aquaculture area (ha)	Area Increase/ decrease ratio[1] (%)	Production (tons)	Production increase/ decrease ratio[1] (%)
1990	1,300		4,339	
1991	1,227	- 5.62	4,979	+ 14.75
1992	1,240	+ 10.60	5,200	+ 4.44
1993	1,080	- 12.90	4,800	- 7.69
1994	1,100	+ 1.85	4,050	- 15.63
1995	1,010	- 8.18	3,678	- 9.19
1999	998	- 0.99	3945	+10.75

Source: Department of Agriculture and Rural Development of HCM, 1996

Note:[1] Increase/decrease ratio is compared to previous year

The evolution since 1990 indicates a reduction in the total water surface of aquaculture production. It is believed that the urbanisation process has caused this reduction as fish-breeding ponds in outlying districts are being filled in to make way for housing and other public construction. This is the main reason behind the recent reduction in periurban agriculture and aquaculture around HCM City.

The giant freshwater prawn (*Macrobrachium rosenbergii*) used to be one of the main freshwater aquatic species reared in periurban regions surrounding HCM City (see Table 2). This species had been raised in periurban districts until 1993.

The prawn was raised year round along the Saigon River, in the Cu Chi district while a single crop per year was harvested during the rainy season in Binh Chanh, and Nha Be districts. In 1993, giant freshwater prawn cultivation was the most widespread in Tan Kien village (Binh Chanh district) where 20 ha of prawn ponds were registered with a yield of one ton/ha/year.

Because of wastewater and other difficulties related to prawn production, such as lack of good seed and poor cultivation efficiency, most periurban water surfaces are now being used for fish production, either on its own or integrated with other agricultural activities.

In general, freshwater aquaculture in periurban areas is conducted in the extensive mode (i.e. fingerlings are supplied but no fish feeding) with adapted fish species (Table 2) such as grass carp, mrigal carp, silver carp, common carp and tilapia. These species were reared because they can feed on natural fodder, which develops in sewage fed systems. In addition, *Clarias* hybrid catfish and the giant gouramy, which needs feeding with artificial fodder like rice bran and trash feed, have been raised for a long time. However, production of the two later species is being reduced due to the decrease of their sales price in the marketplace.

Table 2: Species of fish cultured in periurban areas of HCM City

English name	Vietnamese name	Scientific name
Giant freshwater prawn	Tom cang xanh	*Macrobrachium rosenbergii*
Grass carp	Ca tram co	*Ctenopharyngodon idellus*
Mrigal carp	Ca troi	*Cirrhinus mrigala*
Silver carp	Ca me trang	*Hypophthalmichthys molitrix*
Common carp	Ca chep	*Cyprinus carpio*
Tilapia	Tilapia	Hybrid (*Oreochromis niloticus* x *O. mossambicus*)
Red tilapia	Ca dieu hong	Hybrid
Clarias catfish/walking catfish	Ca tre lai	Hybrid (*Clarias macrocephalus* x *C. gariepinus*)
Pangasius catfish/Mekong catfish	Ca tra	*Pangasius hypophthalmus*
Giant gouramy	Ca tai tuong	*Osphronemus gourami*
Kissing gouramy	Ca huong / ca mui	*Helostoma teminski*
Snakeskin gouramy	Ca Sac ran	*Trichogaster pectoralis*

A. Aquaculture production in periurban districts of HCM City

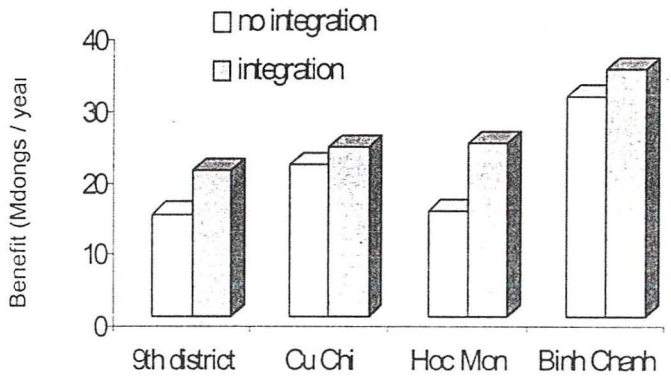
In HCM City, periurban water surfaces account for 80% of the total water surface of the 6 outer districts. The water for aquaculture in the districts of Nha Be and Can Gio is brackish and the water in the 4 remaining districts of Binh Chanh, Cu Chi, Hoc Mon, and 9th district is freshwater. Fish cultivation is mainly carried out in the 4 freshwater districts that possess 90 to 95% of the total periurban water surface and fish production of HCM City.

A survey on aquaculture production was held from March to May 2002 to evaluate the periurban aquaculture systems of HCM City. In the framework of the survey, 73 farmers who cultivate fish in four districts were interviewed. The samples were collected according to water surface areas and the size of aquaculture in each district. The table below describes the distribution of samples and fishpond sizes in four districts

Table 3: Pond surface/household in 4 periurban districts (data collected in the survey).

District	Number of surveyed fish farms	Average size of farms (m^2)
Binh Chanh	30	5,400
Cu Chi	14	3,000
Hoc Mon	10	2,200
9th district	19	3,400

Figure 1: Distribution of water surfaces in four periurban districts.



In HCM City farmers choose the production model and species which most closely correspond to their local conditions (i.e. hydrology, cultivation habits, economic values of products). First of all, they select an appropriate fish species. Tilapia is the most popular species selected for cultivation by farmers in the 9th district, Cu Chi and Binh Chanh districts while the giant gouramy is the most selected species in the Hoc Mon district. Beside the two above mentioned species, other species are reared, such as silver carp, grass carp and common carp. It should be noted that the red tilapia, a new species, is now being raised in the Hoc Mon district. This new fish has high market value and is consumed mostly in restaurants where it is highly appreciated.

Figure 2: Proportion of fish species bred in Binh Chanh district

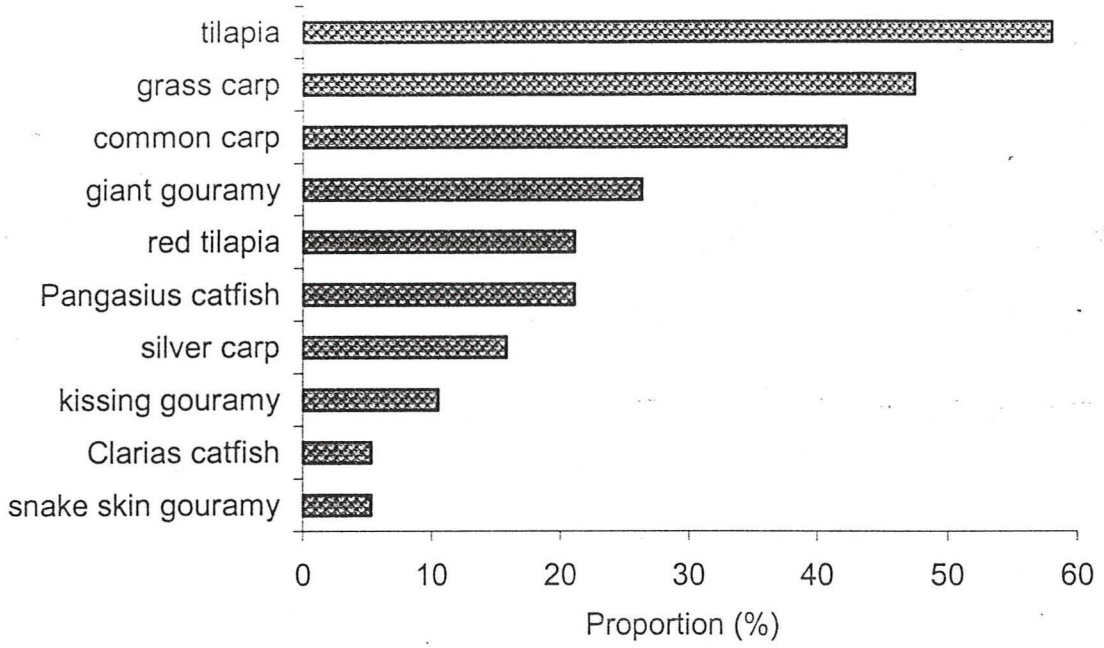


Figure 3: Proportion of species of fish bred in the 9th district.

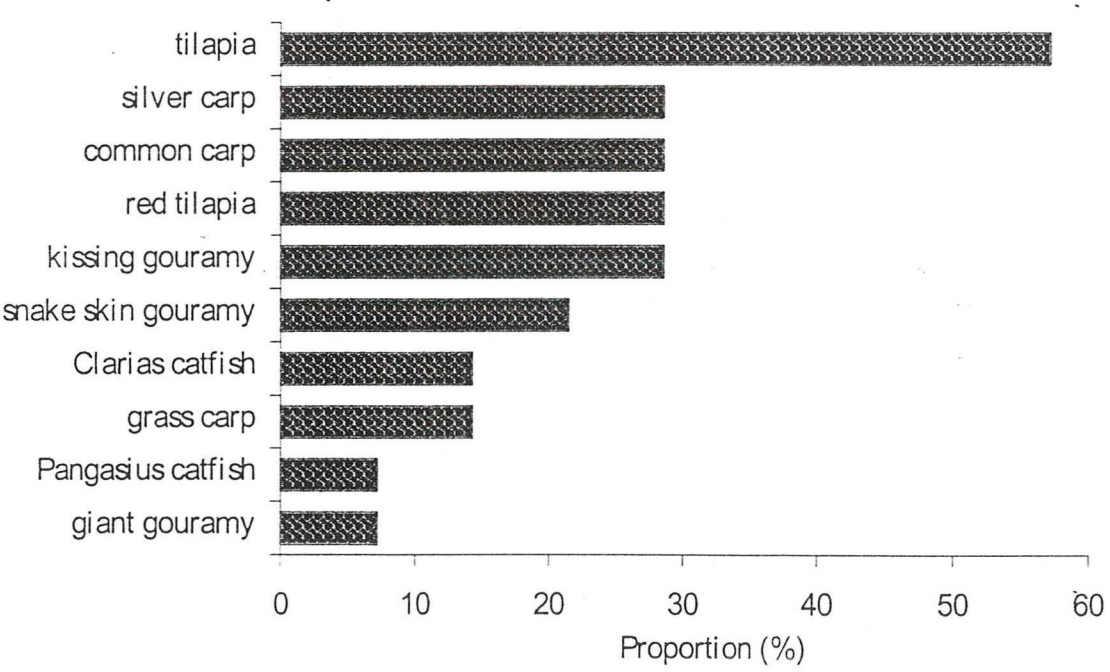


Figure 4: Proportion of fish species bred in the Cu Chi district

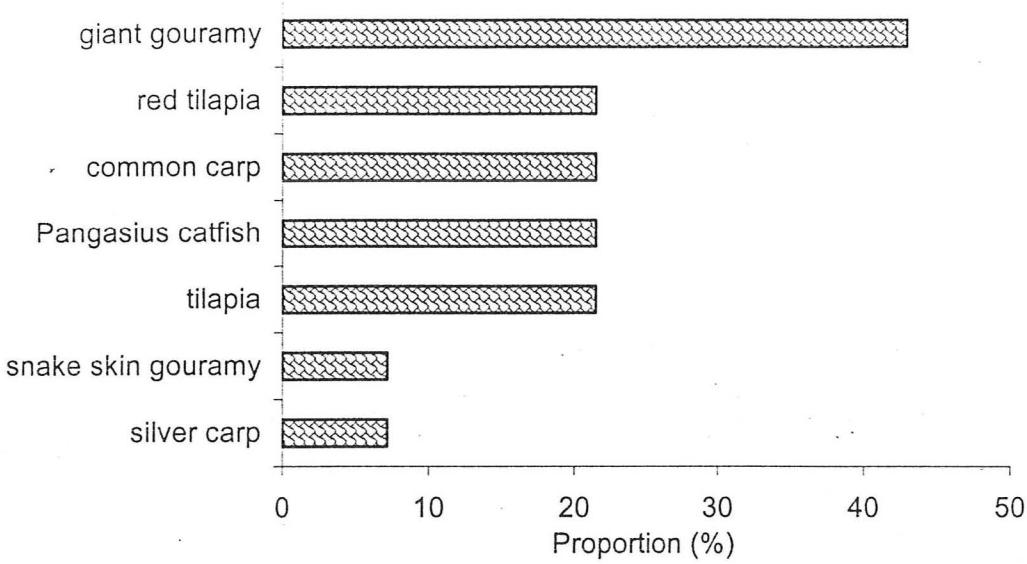
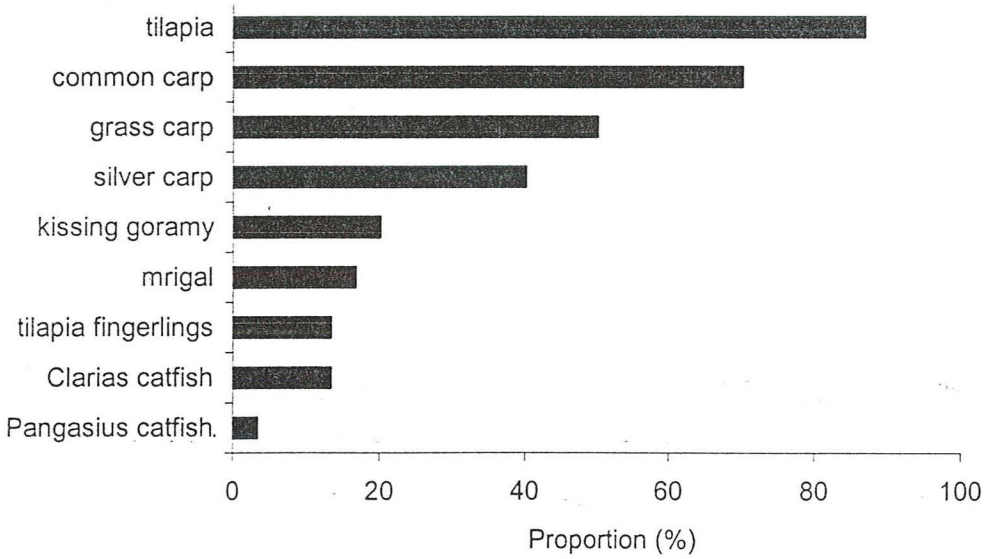


Figure 5: Proportion of fish species bred in the Hoc Mon district



B. Aquaculture systems in the periurban area of HCM city

Periurban aquaculture consists of different models in which farmers make the best use of the nutrients in sewage as natural feed for breeding fish or cultivating highly valued species of fish to supply fresh aquaculture products to restaurants or urban consumers. In general, aquaculture can be divided into monoculture, polyculture and integration with other agricultural activities.

Monoculture

Monoculture means that only one species of fish is reared in a fish-breeding pond. The technique usually used in this production model is intensive cultivation in which one species of fish is fed on artificial feed. In this intensive model, fish do not consume natural feed (i.e. plankton) as fish raised in polyculture models do. Monoculture is not as popular as polyculture in periurban areas due to its high production costs.

Among the 73 surveyed fish farms, only 13 of them used the monoculture model (16.4%). These farms are characterised by a pond size of 200 to 8,000 m^2. Selected species for this model are highly valued fish such as giant gouramy and red tilapia (9^{th} district, Hoc Mon), Clarias hybrid and tilapia (Binh Chanh district). Food varies from farmer to farmer. Cultivators usually feed *Clarias* hybrid catfish and Tilapia with pig or poultry manure. Chicken manure is preferred for its high nutritive value. Other feeds such as rice bran and restaurant waste are also used to raise red tilapia and giant gouramy. Feeding strategies are always geared at minimising production costs by using low cost ingredients.

Polyculture

Polyculture is a system in which farmers raise two or more species of fish at a time. This model allows farmers to take advantage of the natural food in their farms, e.g. phytoplankton, zooplankton and detritus. These natural feeds are consumed by different species of fish with different needs. Some fish prefer water surface layer foods, but others prefer bottom layer foods.

Polyculture is characterised by ponds fertilised with cattle, pig or poultry manure in order to promote the development of natural feed. Farmers take care when selecting fish species so as to avoid food competition. Otherwise, the quantity and quality of manure have to be adapted to the pond size in order to allow for optimal fish density.

Polyculture is the main production model (83.6%) in the periurban areas of HCM City because farmers have had good harvests with this kind of farming. Moreover, the polyculture model is the dominant aquaculture activity in periurban areas thanks to its high efficiency and low production costs. The fish mostly eat foods produced by ponds fertilised by manure or irrigated with nutrient-enriched sewage. Cattle, pig and poultry (chicken, duck, and quail) manure is usually used in fish-breeding farms.

In polyculture, two or more species of fish are bred in the same pond. The main species raised in this model include grass carp, mrigal carp, silver carp, kissing gouramy, common carp and tilapia. Farmers sometimes raise hybrid catfish and Mekong catfish *(Pangasius hypopthalmus*) in polyculture even though these fish are not natural feeders.

Polyculture is popular in many urban and periurban districts surrounding HCM City, especially in Binh Chanh district. Polyculture has proven to be profitable.

Integrating aquaculture with other agricultural activities

In the periurban regions of HCM City, aquaculture production is not separate from other agricultural activities. Aquaculture is very often integrated with husbandry or aquatic plantations.

Integration between fish breeding and pig raising is a common practice in many localities. Pigsties are usually located on the fishpond banks and near farmers' homes for greater convenience. Pig manure and food waste are dropped down to the fishpond directly or collected daily before fertilising the pond. The number of pigs reared is adjusted to match the food requirement of the pond. Farmers usually raise from between 5 to10 pigs on the banks of a 500 to1,000 m^2 pond.

Chicken is only fed with rice bran and other cereals. Due to its high nutritive value, chicken manure can be used as fresh or dried food for fish. It can also be used as fertiliser in agriculture. Since the latter use is popular, chicken manure is sometimes not available for fish breeding. The chicken coop might be placed on the ground or on stilts above the fishpond. On an average, 5,000 fowls are raised per ha of fishpond to provide the pond with a sufficient amount of manure (20 kg/ha/day). Manure might also be brought from other farms to make up for any lack.

Integration between fish breeding and aquatic plants is profitable in canals, which are more or less influenced by city sewage. Several aquatic plants grow well in wetlands, fishponds or canals. Among them, lotus and water mimosas are the two most popular plants cultivated in fishponds. Lotus is usually planted in May or June and the planting period lasts for 5 to 6 months until November or December. In this integration, a crop of lotus is grown per year.

The fishpond is first filled up with water and one week later, lotus shoots are planted. The distance between shoots is 1.5 to 2 m (or 2.2 to 4 m^2 /shoot). The water in the pond is kept at a depth of 0.5 to 0.8 m. The pond then is stocked with fish 1 to 2 weeks after the lotus is planted. Tilapia is a common species of fish raised in lotus ponds but other freshwater species might include common carp, silver carp, kissing gouramy, mrigal carp and grass carp. The average stocking density is 4 to 5 fingerlings/ m^2. The fish feed on natural food in the pond and artificial feed can be usual fish food such as duck weed or rice bran. Fish are harvested once, usually one week after the lotus has been harvested. The average yield of lotus is 200 to 300 kg/ 1,000 m^2.

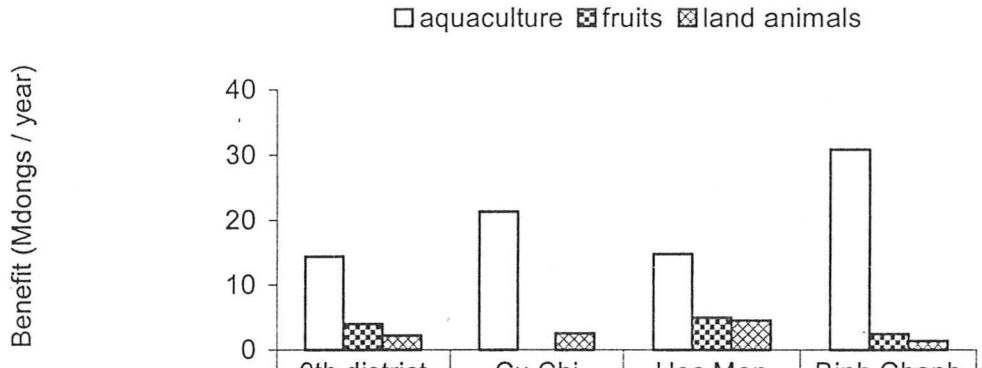
Water mimosa is often planted 2 to 3 days after filling the pond up with water and it is harvested two months later. This plant is usually fertilised with urea twice a week even though the water is fertilised by sewage. Fingerlings are also stocked in water mimosa ponds. This integration is an especially appropriate model in highly polluted areas.

C. Economic analysis of the different periurban aquaculture systems

In addition to aquaculture production, farmers in the periurban districts of HCM City also plant fruit trees and rear cattle. However, the cost and benefit analysis in figure 6 shows that aquaculture yields a greater profit than fruit tree and livestock cultivation.

The profits from aquaculture production are normally 5 to 10 times higher than other agricultural activities. For example 34 million dong/household of aquaculture when compared to 2,4 million dongs and 1,39 million dongs/ household of fruit tree and livestock farming respectively.

Figure 6: Households' annual profit from aquaculture, fruit cultivation and animal husbandry



	9th district	Cu Chi	Hoc Mon	Binh Chanh
aquaculture	14.42	21.29	14.80	30.82
fruits	4.00	0.00	5.00	2.45
land animals	2.21	2.57	4.53	1.39

Out of the 4 districts, households in Binh Chanh have larger water surfaces for fish breeding. Therefore, they make more money from aquaculture than farmers in other districts (Table 4). In addition, the profits from aquaculture are higher than those from rice farming. Out of the three activities, husbandry brings the lowest profit in comparison with fruit tree farming and fish breeding. The profit trends are derived from households practising all three activities.

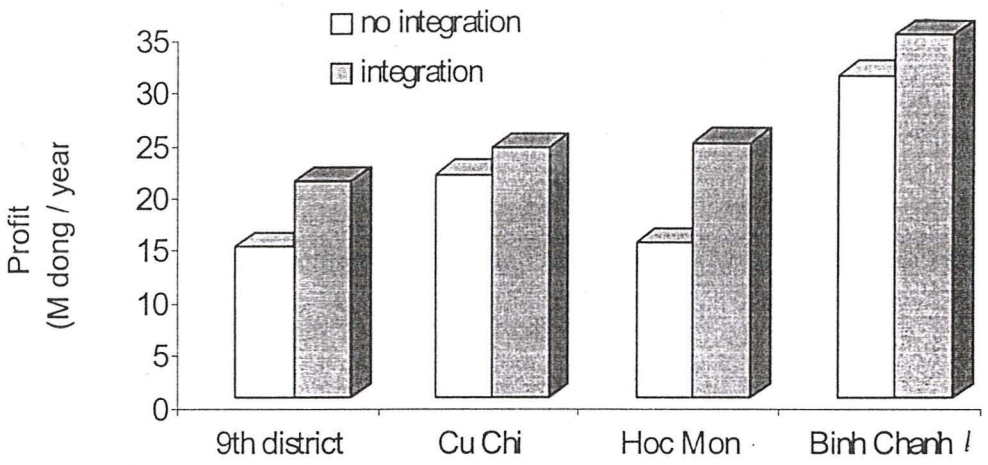
Table 4: Annual profit from key agricultural activities/household in four surveyed districts

District	Surface of Ponds (m^2)	Profit from aquaculture (Mdong)	Profit from Fruit trees (Mdong)	Profit from Land animals (Mdong)	Total Profit (Mdong)
9^{th} district	3,400	14.4	4.0	2.2	20.6
Cu Chi	3,000	21.3	0.0	2.6	23.9
Hoc Mon	2,200	14.8	5.0	4.5	24.3
Binh Chanh	5,400	30.8	2.5	1.4	34.7

Mdong = one million dongs are equivalent to USD 60

Aquaculture is either monoculture or is integrated with other agricultural activities. Figure 7 indicates that integration always brings more profit to farmers than monoculture. This is due to the fact that integrated agriculture saves food and is low on other production costs.

Figure 7: Annual profit/household from aquaculture with or without integration model



D. Problems and expectations of periurban fish farmers

Fish farmers are often confronted with problems relating to techniques, socio-economic problems and environmental concerns as can be seen below:

- Farmers, especially the poor, usually suffer from a shortage of credits for leasing or buying lands to enlarge the surface of their ponds.
- Farmers do not have enough information and proper aquaculture production skills.
- Water sources from rivers, canals are increasingly harmful for the fish raised in ponds due to toxic substances in sewage from industrial production units.
- Unpredictable variations in the sales price of fish in the urban market lead to unstable aquaculture production in periurban districts.

Even though there are many obstacles to aquaculture production, fish farming still contributes a great amount of income to a large number of farmers living in the periurban regions of the city. However, farmers want higher incomes and greater security from their production. Their expectations have been recorded in the survey as follows:

- To be taught about new aquaculture techniques through workshops for fish farmers,
- To receive new species of fish which are appropriate for periurban aquaculture production,
- Water sources for aquaculture must be purified, especially in Binh Chanh district,
- Fish prices must be stabilised so farmers can plan ahead,
- Access to necessary loans for investment must be made easier.

E. Conclusion

The present production of aquaculture in the periurban areas around HCM City is well adapted to the environment and the economic context. Polyculture and fish culture/livestock or aquatic plant integration are the dominant activities. Tilapia is the main species. However, other species such as giant gouramy and carp are also raised in periurban areas.

Profit-cost analysis shows that the integration model of aquaculture (ie. livestock, fruit tree farming) is more profitable than monoculture. The average annual income/household of polyculture reaches 25.9 million dongs and 20.3 million for each household practising monoculture or integrated aquaculture.

Fish farmers are faced with a lack of capital, insufficient trade skills and water pollution, particularly in villages near inner districts such as Tan Kien and An Lac.

2. MODELING OF FISH PRODUCTION SYSTEMS IN HCM CITY

In order to develop a model for fish farming in HCM City, especially for Binh Chanh district, a digital map of HCM City has been created and modified to reflect the existing conditions in a reliable form. Data are being collected to clearly define the existing aquaculture status of HCM City.

II. COMPONENT II- SUPPLY AND DEMAND ANALYSIS AND CONSUMPTION BEHAVIOUR

Different surveys have been undertaken on the fish commodity chain: (1) retail markets, (2) wholesale markets in HCM City and (3) fish suppliers from provinces in the south of the city. Since the collected data are still being processed, this document only indicates the primitive analysis on the retail and wholesales markets in HCM City.

1. RETAIL MARKET

During the survey, 122 fish traders and consumers in the retail markets were engaged in the interview section. These interviewees were selected from 22 districts of HCM City:

- In 16 inner districts: districts 1 to 12 and Binh Thanh, Go Vap, Phu Nhuan and Tan Binh; 105 traders were interviewed.

- In the 4 outer districts of Binh Chanh, Cu Chi, Hoc Mon and Nha Be, 17 traders were interviewed.

Out of the 4,004 tons of fish consumed per year, the quantity of fish sold by interviewed retailers only accounts for 2.5% (equivalent to 162,000 tons per year) of the HCM City aquaculture market. The average quantity of fish that each retailer deals in per day reaches 90 kg[1], of which 34 kg are freshwater fish and 56 kg are marine fish (38% and 62%, respectively).

The survey focused on species of freshwater fish since the project concerns periurban aquaculture, which is mostly freshwater fish production.

Twenty freshwater species are sold in HCM City with the top three representing 61% of the total quantity (Figure 2.8). Snake-head fish is the most popular (37%) and then hybrid catfish (14%) and Tilapia (10%). Three other species (red tilapia, common carp, giant gouramy) also have a large share of the market (> 5%) and the 14 others are minor species (< 5%). Each retailer sold between 1 and 8 species. The average price of freshwater fish is 24,300 dongs per kilo. Fish names are detailed in Table 5.

Freshwater fish are much more expensive than the most popular marine fish (mackerel, 6,000 -10,000 dongs per kilo). On average, freshwater fish are cheaper than poultry (28,000-30,000 dong per kilo), pork (32,000 dong per kilo) and beef (50,000 dongs per kilo).

Retailers buy the fish from middlemen and from the wholesale markets. The telephone is used to contact suppliers and customers by 33% and 25% of the retailers, respectively. There are no contracts with the suppliers but different agreements (oral contracts, informal agreements, and acquaintances) are arranged with customers by 34% of the retailers.

[1] : The daily quantity of fish sold by retailers' ranges from 17 kg to 250 kg.

Table 5: Names of the freshwater fish sold in the HCM City markets

Vietnamese name	English name	Scientific name	Origin	
			Aquaculture	Fishery
Ca loc	Snakehead fish	*Channa* sp.	+ + *C. micropeltes*	+ + *C. Striata*
Ca tre lai	Walking catfish	Hybrid between *Clarias macrocephalus* and *C. gariepinus*	+ + +	+
Tilapia	Tilapia	Local strain of hyrid *Oreochromis niloticus* and *O. mossambicus*	+ + +	+
Ca chep	Common carp	*Cyprinus carpio*	+ + +	+
Ca tai tuong	Giant gouramy	*Osphronemus gouramy*	+ + +	+
Ca dieu hong	Red tilapia	Artificial species from the hybridisation of several species	+ + +	+
Ca ro dong	Climbing perch	*Anabas testudineus*	+	+ + +
Luon dong	Swamp eel	*Fluta alba*	0	+ + + +
Ca tram co	Grass carp	*Ctenopharyngodon idella*	+ + +	+
Ca bong lau / Ca dua	Krempfi catfish	*Pangasius krempfi*	0	+ + + +
	River catfish	*Pangasius kunyit*	+	+ + +
Ca me :				
- Ca me hoa	Silver carp	*Hyophthalmichthys molitrix*	+ + + +	0
- Ca me trang	Bighead carp	*Aristichthys nobilis*	+ + + +	0
- Ca me vinh	Silver barb	*Puntius javanicus*	+ + +	+
Ca tra	Pangasius catfish	*Pangasius hypophthalmus*	+ + +	+
Ca bong mu	Goby	Oxyelotridae	0	+ + + +
Ca hu	River catfish	*Pangasius conchophilus*	+ + +	+
Ca mui	Kissing gouramy	*Helostoma teminski*	+ + + +	0
Ca sac rang	Snake skin gouramy	*Trichogaster pectoralis*	+ +	+ +
Ca tre vang	Walking catfish	*Clarias macrocephalus*	+ +	+ +
Ca ba sa	Bocourti catfish	*Pangasius bocourti*	+ + +	+
Ca bong dua	Goby	Oxyelotridae	0	+ + + +
Ca that lat	Feather back fish	*Notopterus notopterus*	+	+ + +

Table 6: Assessment of trade results for the retailers (average calculations).

	Per kilo	Per retailer per month (1026 kg)	
1) Sales of fish (dong)	24,324	24,953,607	100 %
2) Investment (dong)*	29	29,440	0.1 %
3) Purchase of fish (dong)	22,791	23,381,803	93.7 %
4) Salary (dong)	676	693,033	2.8 %
5) Caretaking (dong)	436	447,131	1.8 %
6) Total expenses (dongs) (2+3+4+5)	23,932	24,551,407	98.4 %
7) Margin on fish sales (dongs) (1-3)	1,532	1,571,803	6.3 %
Net result (dongs) (1-6)	392	402,199	1.6 %

*: Depreciation of the investment calculated over 20 years.

For an average sale price of 24,300 dongs per kilo, the profit for the retailer is 392 dongs per kilo. The monthly profit for the retailer is about 402,000 dong. The main cost is the purchase of fish (93.7% of the sales). Despite small profits, the retailers do not take out any loans.

According to the retailers, fish supply meets and even exceeds demand for 17 out of 20 species (Table). In particular, demand is satisfied for the six main species. There is a lack of supply for three species: Climbing perch, Goby and feather back fish. Climbing perch is indeed short in supply but it is a valuable species (29,800 dongs per kilo) traditionally appreciated for "Climbing perch cooked in bowl" (a particular local dish). Despite the development of aquaculture, the market supply for climbing perch remains dependent on the capture of wild fish. One sort of goby is also a small, wild fish which is traditionally appreciated although it is less popular than climbing perch. Feather back fish is very popular since its boneless flesh is used for several traditional dishes. This species is supplied by the fishing industry, since aquaculture of feather back fish is still at an experimental stage. Krempfi catfish seems to saturate the market despite its relatively high value (29,900 dongs per kilo). This species might be misnamed and be confused with other *Pangasius*. Krempfi catfish is only caught in the wild since aquaculture of this species has not yet been developed.

Table 7: Balance between supply and demand as perceived by the fish retailers. The dominant perception is marked with shading.

Species	Supply < demand (%)	Supply = demand (%)	Supply > demand (%)	No retailers
Snakehead fish		55	45	73
Hybrid catfish		53	47	38
Tilapia		74	26	27
Common carp		68	32	22
Giant gouramy	5	57	38	21
Red tilapia	26	37	37	19
Climbing perch	46	23	31	13
Swamp eel		89	11	9
Grass carp		60	40	5
River catfish		25	75	4
Silver carp		75	25	4
Pangasius catfish		100		3
Goby		50	50	2
River catfish		100		2
Kissing gouramy		50	50	2
Snake skin gouramy		100		2
Walking catfish		100		2
Bocourti catfish		100		1
Goby	100			1
Feather back fish	100			1

The positive evolution of the fish market seems to be only slightly perceived by both customers and retailers (Table). On top of this, they have different perceptions. Thus, we should consider the following trends carefully:

The rise of the market share for river catfish, Climbing perch, Common carp, Giant gouramy and Tilapia. River catfish is an interesting species which has both good quality (boneless, tasty flesh) and a relatively low price (17,100 dongs per kilo). Aquaculture of this species is developing in the Mekong delta. The rise expected for climbing perch strengthens the high demand relative to supply (Table).

Decrease of the market share for grass carp, swamp eel and Snakehead fish. The lower demand for swamp eel could be due to price increases (now 39,400 dongs per kilo) which are caused by short supply. The last species is supplied by the fishing industry, although aquaculture is still at an experimental stage.

Table 8: Changes in demand by species as perceived by the customers and the retailers. Various numbers of customers were interviewed near the associated retailers.

Species	Customers (%)			Retailers (%)			N retailers
	Decrease	Constant	Increase	Decrease	Constant	Increase	
Snakehead fish	1	99			100		73
Hybrid catfish		100			100		38
Tilapia		100			96	4	27
Common carp		96	5		100		22
Giant gouramy		95	5		100		21
Red tilapia		100			100		19
Climbing perch		100			85	15	13
Swamp eel	11	89			100		9
Grass carp		100		20	80		5
Krempfi catfish		100			100		4
Silver carp		100			100		4
Pangasius catfish		100			100		3
Goby		100			100		2
River catfish		100			50	50	2
Kissing gouramy		100			100		2
Snake skin gouramy		100			100		2
Hybrid catfish		100			100		2
Bocourti catfish		100			100		1
Sand Goby		100			100		1
Feather back fish		100			100		1

2. WHOLESALE MARKET

A survey was conducted in the following wholesale and urban markets of HCM City:

The quantity of fish sold per wholesaler is much higher in Ong Lanh market than in the two others[2]. The cumulative daily quantity sold by the 16 traders interviewed is 24.5 tons. The estimated yearly quantity is 8,935 tons which represents 5.5% of the total fish market in HCM City (162,000 tons).

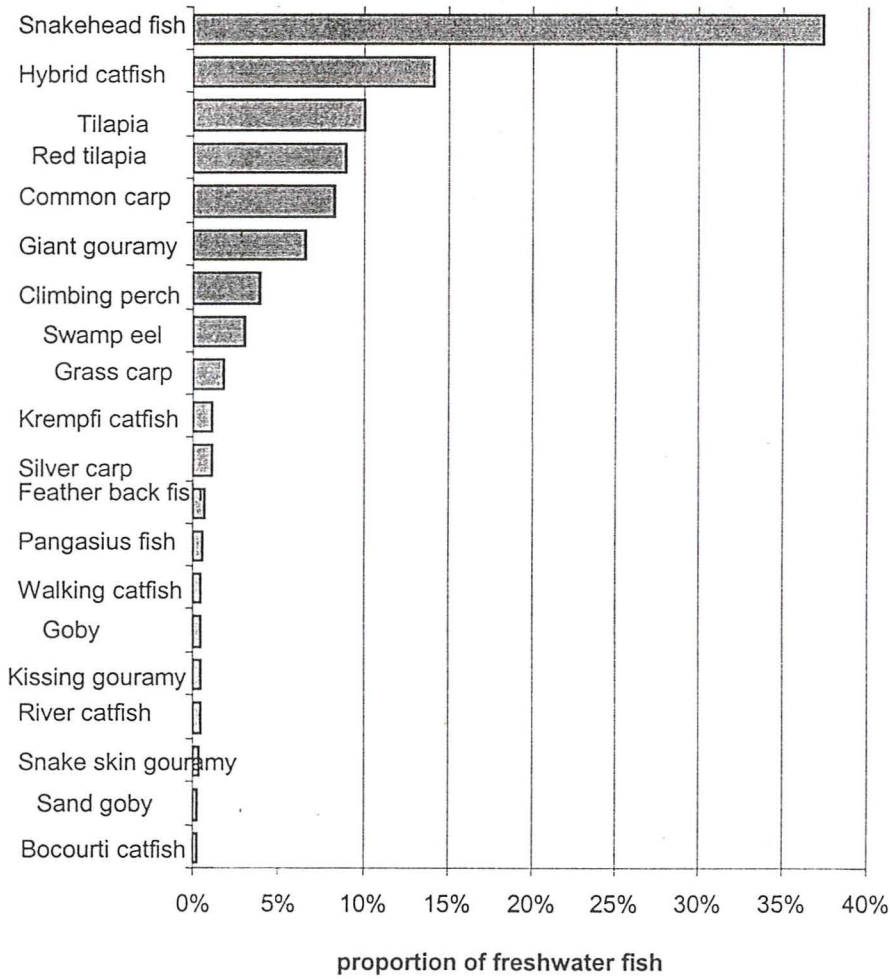
Market	District	Number of wholesalers interviewed	Average quantity of freshwater fish sold per wholesaler (kilo per day)
Xom Cui	8	6	575
Ong Lanh	1	6	3417
San Ca 50	5	4	133

[2] : The range for the daily quantity sold per wholesaler ranges from 180 kg to 6000 kg.

Thirteen freshwater species are sold at the three wholesale markets. However, the first three species, Hybrid catfish, Snakehead fish and giant gouramy, represent 76% of the total quantity. The average sales price for all the species is 14,407 dongs per kilo.

Almost all the fish come from the Mekong Delta: from the provinces of An Giang, Dong Thap, Can Tho, Tien Giang, Ca Mau and Long An. Fish from periurban aquaculture around HCM City represent 3% of the Giant gouramy and red tilapia species. The last species is also obtained from the Mekong Delta.

All the wholesalers sell to retailers. Five wholesalers also sell fish to other wholesalers and two wholesalers sell their fish directly to restaurants (Giant gouramy and red tilapia).



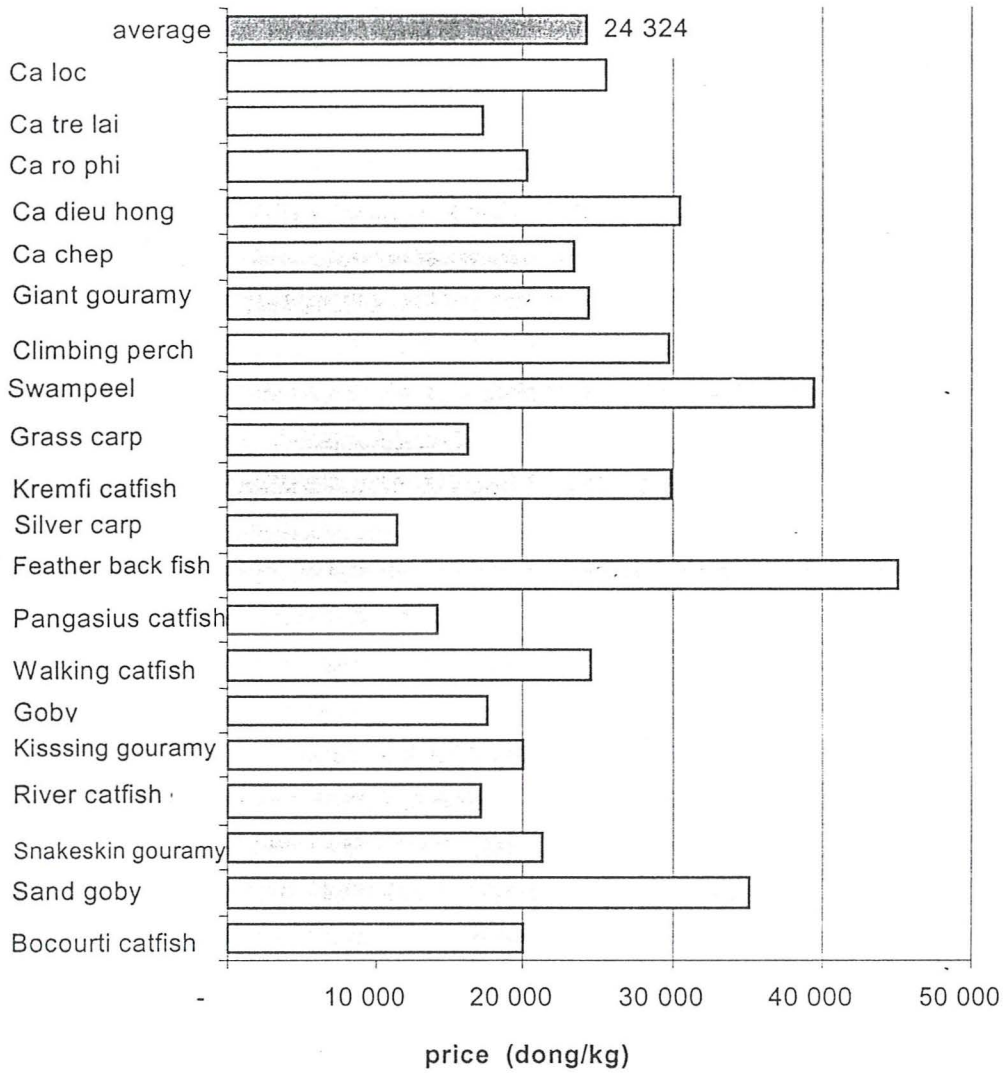


Figure 8: Proportion of the different freshwater fish species sold on the retail markets in HCM City (left) and average sales price (right).

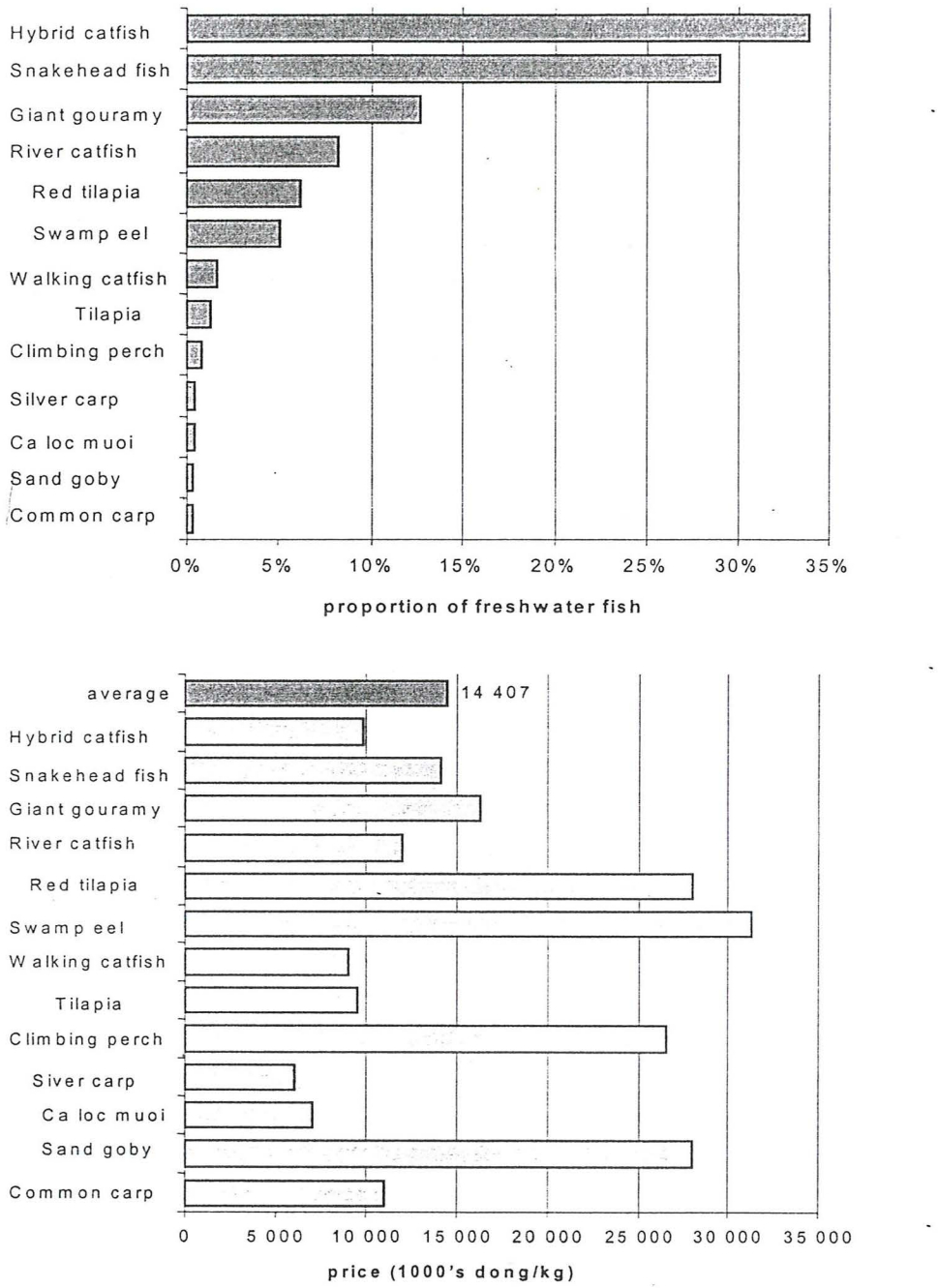


Figure 9: Proportion of the different freshwater fish species sold on the wholesale markets in HCM City (left) and average sales price (right).

III. COMPONENT III- TECHNICAL AND INSTITUTIONAL INNOVATIONS FOR PERI-URBAN AQUACULTURE DEVELOPMENT IN HCM CITY

In this component, 3 sub-sections were implemented by HCM City partners and the first year of the project gave the following results:

1. TECHNOLOGY TRANSFER TO FARMERS IN PERIURBAN AREAS

As in the proposal for the first year, the GIFT strain of Tilapia and red tilapia were promoted for development at some sites in the periurban areas around HCM City.

- Seven farmers received GIFT strains from the project to raise in sewage treatment systems in Binh Chanh. The fish were cultured in April but have not yet been harvested. Farmers were interested in using new strains of Tilapia and they observed that the fish grew faster than local strains.
- Two farmers received Red tilapia to raise. However, due to the fact that the project started late in April it was not possible to release fingerlings. Therefore, only 2 farmers participated in this sub-section.

The plan for next year is to develop 9-10 farms with an emphasis on GIFT strains and Red tilapia.

2. EVALUATION OF HEAVY METALS IN FISH AND INNOVATIONS FOR RISK REDUCTION METHODS FOR HEAVY METAL ACCUMULATION IN FISH CULTURED IN SEWAGE SYSTEMS

HCM City is a commercial and industrial centre and most manufacturing plants located in urban areas do not have water treatment systems. As a result, effluent from these plants is poured directly into the sewage system, creating water that is not only polluted in organic matter but also inorganic matter including dangerous heavy metals.

There is much information related to heavy metal accumulation in aquatic products derived from polluted areas. In Vietnam, there has not yet been a study on the matter. As a result, in the sub-component, cultured fish were collected at 2 sites (highly polluted, close to the city) and 2 other sites (less polluted, far away from the city) for evaluation.

Five fish species that are commonly cultured in the region were sampled. The duration for a culture cycle is 6 months and fish were collected at harvest. The results of fish samples from two highly polluted sites are presented in tables 9 and 10.

Table 9: Heavy metal accumulation in canal waters of HCM City when compared to river waters.

Canal or river	Heavy metal accumulation (µg/l)				
	Cd	Cr	Cu	Pb	Zn
Nhieu Loc, Thi Nghe system	1-3	15-20	12-30	5-140	100-500
Cau Bong canal	7-8	15-18	18-25	7-300	395-650
Tan Hoa system	3-4	20-22	20-72	10-20	150-800
Kenh Doi-Te, Tan Hu, Ben Nghe system	2-7	12-19	10-180	10-160	200-250
U cay canal	2-6	8-10	8-85	30-350	690-900
Non polluted river water	0.5	1	3	0.5	10
Maximal accumulation of heavy metal	16	22	60	700	90

Source: VN soil science association

Table 10: Heavy metal accumulation in fish muscle collected from Phong Phu village (heavily polluted)

Fish	Samples	Cd (mg/Kg)	Cu (mg/Kg)	As (mg/Kg)	Zn (mg/Kg)	Pb (mg/Kg)
Limit levels *		1.0	50.000	1.00	50.00	2.00
Pangasius	Co – T11	0.196	0.343	ND	5.989	ND
	Co – T12	0.092	0.321	ND	5.524	ND
	Co – T13	0.147	0.842	ND	9.567	ND
Tilapia	Co – P11	0.123	0.287	ND	6.037	ND
	Co – P12	0.137	0.697	ND	9.248	ND
	Co – P13	0.084	0.241	ND	6.333	ND
Common Carps	Co – C11	0.095	0.505	ND	23.353	ND
	Co – C12	0.074	0.576	ND	46.008	ND
	Co – C13	0.023	0.402	ND	23.425	ND
Silver carps	Co – M11	0	0.242	ND	6.161	ND
	Co – M12	0.012	0.323	ND	6.529	ND
	Co – M13	0.12	0.565	ND	5.562	ND

Limit levels for fish and meat (Ministry of Public Health, Vietnam)

ND: Not detected

Table 11: Heavy metal accumulation in fish liver collected from Phong Phu village (heavily polluted).

Species	Samples	Cd (mg/Kg)	Cu (mg/Kg)	As (mg/Kg)	Zn (mg/Kg)	Pb (mg/Kg)
Limit levels *		1.0	50.000	1.00	50.00	2.00
Pangasius	Gan –T11	0.024	17.612	ND	36.741	ND
	Gan –T12	ND	18.17	ND	36.543	ND
	Gan –T13	0.149	22.367	ND	55.681	ND
Tilapia	Gan - P11	0.123	3.513	ND	20.298	ND
	Gan – P12	ND	6.877	ND	13.619	ND
	Gan – P13	0.167	2.959	ND	36.195	ND
Common Carps	Gan – C11	0.553	9.051	ND	19.513	ND
	Gan – C12	0.236	32.675	ND	40.989	ND
	Gan – C13	0.269	15.033	ND	71.143	ND
Silver Carps	Gan – M11	0.196	1.178	ND	11.915	ND
	Gan – M12	0.151	3.798	ND	16.825	ND
	Gan – M13	0.144	16.356	ND	23.326	ND

Limit levels for fish and meat (Ministry of Public Health, Vietnam)

ND: Not detected

The results show that fish cultured in the region have higher Zinc (Zn) levels in the liver than indicated in Ministry of Public Health guidelines. However, fish flesh has not accumulated heavy metals. Pangasius catfish and common carps are two bottom feeders that seem to be more sensitive than other species.

Table 12: Heavy metal accumulated in fish muscle collected in An Lac. (Polluted area)

Species	Samples	Cd (mg/Kg)	Cu (mg/Kg)	As mg/Kg)	Zn (mg/Kg)	Pb (mg/Kg)
Limit levels *		1.0	50.000	1.00	50.00	2.00
Tilapia	Co - R11	0.028	0.339	6.081	11.437	0.743
	Co - R12	0.038	0.290	4.808	11.614	0.381
	Co - R13	0.069	0.312	6.001	14.382	0.397
Common Carps	Co - C11	0.038	0.310	4.812	18.906	0.381
	Co - C12	0.088	0.249	4.247	18.863	0.781
	Co - C13	0.074	0.234	5.785	17.697	0.555
Kissing Gouramy	Co – M11	0.084	0.245	4.117	11.719	0.477
	Co – M12	0.085	0.303	4.620	12.404	0.425
	Co – M13	0.115	0.506	ND	12.347	0.730
Grass Carps	Co – TC11	0.100	0.234	ND	14.520	0.399
	Co – TC12	0.100	0.365	ND	12.469	0.599
	Co – TC13	0.100	0.245	ND	12.780	0.500

Limit levels for fish and meat (Ministry of Public Health, Vietnam)

ND: Not detected

Table 13: Heavy metal accumulated in fish liver collected in An Lac (Polluted area)

Species	Samples	Cd (mg/Kg)	Cu (mg/Kg)	As (mg/Kg)	Zn (mg/Kg)	Pb (mg/Kg)
Limit levels *		1.0	50.000	1.00	50.00	2.00
	Gan -R11	0.254	11.822	ND	22.951	1.271
Tilapia	Gan -R12	0.324	16.235	ND	26.254	1.389
	Gan -R13	0.368	14.05	ND	52.363	1.3
	Gan - C11	0.136	10.835	ND	69.788	0.454
Common Carps	Gan - C12	0.151	3.951	ND	61.944	0.71
	Gan - C13	0.146	6.972	ND	44.316	0.666
	Gan -M11	0.147	1.278	ND	26.33	0.401
Kissing Gouramy	Gan -M12	0.144	8.279	ND	37.392	0.332
	Gan -M13	0.106	2.845	ND	15.191	KPH
	Gan -TC11	0.153	14.841		29.226	0.546
Grass Carps	Gan -TC12	0.182	17.414		55.073	0.642
	Gan -TC13					

Limit levels for fish and meat (Ministry of Public Health, Vietnam)

ND: Not detected

The results in table 12 and 13 show that heavy metal accumulation in the An Lac region is more serious than in Phong Phu village. At An Lac sites, As and Zn levels in flesh and liver are very high, six times the limit for As and 1.4 times greater than Ministry of Public Health guideline limits. The analysis reflects the origin of the sewage. The An Lac sewage systems receive effluent from areas where different factories are located including dyeing, chemical and battery production.

Besides analysis of heavy metal accumulation in fish, a study is underway to evaluate methods for reducing heavy metal accumulation by stocking fish at harvest time in non-polluted areas according to a hypothesis that accumulated levels will decrease. Five hundred Tilapia at harvest were transferred to the experimental farm (UAF) to finish their production cycle. Fish were sampled every 15 days to analyse their heavy metal content. The experiment started in October. Fish samples have not yet been completely analysed. Therefore, the content and conclusion of this component have been deferred to next year's plan.

3. INDUCED SPAWNING IN FISH SPECIES SHOWING POTENTIAL FOR AQUACULTURE DEVELOPMENT IN PERIURBAN HCM CITY

STUDY ON PROPAGATION AND NURSING OF

GREEN CATFISH (MYSTUS SP.)

Abstract

Green catfish (*Mystus* sp.) broodstock were collected from Song May and Tri An reservoir located in Thong Nhat district, Dong Nai province (150 km north of HCM City). The fish were stocked in 300 m^2 earthen ponds at the experimental aquaculture farm administered by the Faculty of Fisheries, University of Agriculture and Forestry, Ho Chi Minh City. The broodstock was fed daily with a diet of 4 to 7% body weight containing 50% of processed fish trash and 50% rice bran.

Spawning was induced using LH-Rha with Domperidone. The hormone was administered dorsally in a single injection. The eggs were stripped 10 to 11 hours after injection at 29.5 to 30°C. Fertilised eggs were incubated in funnel jars. Hatching occurred after 20 hours at a water temperature of 30°C. Fecundity rates were 126,364 to 142,000 eggs per kg. Egg size was relatively small from 1.17 to 1.32 mm in diameter and fertilised eggs were brown–yellow in colour.

Larval rearing and fry nursing were undertaken in 1m^3 plastic and glass tanks. The larvae were fed Moina[3] from the third day after hatching. Then, fry fed (dressing the water surface) Tubifex[4] and Moina from the fourth day. At 14 days fingerlings gained 16.4 to 18.7 mm in length and their survival rate ranged from 78 to 92%.

A. Introduction

Green catfish (*Mystus* sp.) is a local fish species distributed in freshwater or slightly brackish water in Eastern areas of South Vietnam and the Mekong Delta such as rivers, streams, ponds, reservoirs and river mouths. The fish is a catfish species with high economic value because of its high quality meat. Presently the price of fresh fish varies from 30.000 to 60.000 VND/ kg depending on season and fish size. Therefore, commercial production has decreased significantly due to over-fishing and unsuitable resource management. A study of green catfish propagation is needed for periurban areas in order to develop sustainable aquaculture and conservation strategies.

B. Methodology

This study will be carried out at the experimental farm over a 2 year period (2002 – 2004). Green catfish broodstock are collected from Song May and Tri An reservoir Thong Nhat district, Dong Nai province. Fish were acclimatised and are being reared in a 300m^2 earthen pond with a water depth of 1.2 m (since March 2002). Fish are fed a mixture of 50% fresh processed fish trash and 50% rice bran. Diets for the broodstock change with the development of gonads, and vary from 4 to 7% of body weight. Fish are fed 3 times per day.

b.1. Fish propagation experiment:

Spawning was induced using LH-RHa and DOM (Domperidome) and divided into 3 lots dosed as follows:

[3] A small aquatic organism (a kind of zooplankton).

[4] A turbificid worm.

Lot 1: 60 μg LH – RHa and 5mg DOM/kg for female

Lot 2: 70 μg LH – RHa and 5mg DOM/kg for female

Lot 3: 80 μg LH – RHa and 5mg DOM/kg for female.

Each experimental lot used both artificial and natural propagation. In natural spawning, broodstock were released into cement tanks for mating after LH- RHa injection. In artificial propagation, fertilised eggs were incubated in 4 L-Weis jars (funnel type) after removal of the natural protective larval jelly by the carbamide method. In natural spawning, fertilised eggs incubated in 1 m^3 composite tanks at a slow rate.

b.2. Nursing fry to fingerling:

After hatching, fry were nursed in composite tanks and plastic lined tanks until the yolk sacs were completely absorbed. The nursing experiment is composed of 2 stages:

- Stage I: Nursing fish from 3 to 14 days.
- Stage II: Nursing fish from 14 - 28 days.

Stage I (3- 14 days)

When fries were 3 days old, they were cultured in 120 litre aquariums containing 50 ml of water. The experiment included 2 feed variables and allocated into a completely randomised block design.

Variable 1: *Moina* feed

Variable 1: *Artemia* feed

Each variable included 3 lots in nursing densities set at:

+ Lot 1: 8 fry/L
+ Lot 2: 10 fry/L
+ Lot 3: 12 fry/L

Each lot has 3 replications. Fry were fed with Moina or Artemia for the first 2 days (4 & 4 days old). Then all experimental fish were fed with Tubifex.

Stage II (14 – 28 days):

In this stage, fish were nursed in composite tanks and hapas, which are rectangular boxes made of close-meshed netting cloth, in earthen ponds. Each nursing device has 3 lots with the following nursing densities:

- Lot 1: 400 fry/ m^3
- Lot 2: 600 fry/ m^3
- Lot 3: 800 fry/ m^3

All experimental fish were fed with Tubifex until they were 20 days old. This feed was gradually changed to floating pellet feed made by the Cargill Company with a 30% protein content. Every week, growth rates were recorded. All data is analysed in ANOVA, using SPSS software.

C. Results

Artificial Propagation

After 4 months of acclimatising and nursing in earthen ponds with a feed of processed trash fish and rice bran, 80% of the broodstock had naturally matured. Spawning was carried out using two methods: artificial propagation and natural spawning.

Table 14: Artificial propagation of Green catfish (water temperature: 29.5 – 30^{0}C)

Spawning Time	Experimental lot	Spawning Method	Number of female	Spawning rate (%)	Real fecundity (eggs/kg)	Fertilization rate (%)
I	1	Artificial Propagation	3	100	126,364	30
	2		3	100	132,500	36
	3		3	100	142,000	34
II	1		3	100	130,900	28
	2		3	100	132,000	32
	3		3	100	140,000	46
III	1	Natural spawning	3	100	124,800	82
	2		3	100		
	3			100		

Table 9 shows that, LH-RHA induces good spawning in green catfish at doses of 60–80μg LH-RHa/ kg female. Highly matured male fish give the best results in spawning with a high fertilisation rate for artificial propagation. In artificial propagation, the effecting time of LH-RHa on green catfish is 10-11 hours at a water temperature of 29.5 -30^{0}C. In natural spawning, green catfish start to spawn about 9 –10 hours after LH – RHA injection, and their spawning time is 1 to 1.3 hours. There are differences in LH–RHA effects on green catfish depending on the spawning methods. In addition to the effects of LH-RHA on inducing spawning, the presence of male fish also stimulates female fish spawning.

According to a report from the FFRC (Freshwater Fisheries Research Centre) (1996), the effecting time of Ovaprim on yellow catfish is 14 hours (one dose injection). The difference in effecting time is due to the activation of both breeding stimulating substances and differences in water temperature in the two studies.

The results show that practical fecundity of Green catfish is very high, ranging from 126.364 to 142.000 eggs/kg in artificial propagation and 124.800 eggs/kg in natural spawning. Fecundity of green catfish, in general, is higher than that of walking catfish because of their high nurturing rate and smaller eggs. Fertilised eggs are 1.17 -1.32 mm in diameter.

During spawning time III, the fertility rate for natural spawning is much higher than in artificial propagation. This difference is due to the low quality of male testis. It has been noted during the dissection of male fish that their testis are small and bright red In colour.

and female fish in natural spawning conditions release and fertilise when stimulated by the opposite mature sex.

Table 15: Result of eggs incubating (at a water temp of 29,5 – 30^{0}C)

Spawning Time	Spawning method	Collected eggs (eggs)	Survival rate of 3 day old fish	Number of 3 day old fry
I	Artificial	124.600	80	27.112
II	Propagation	112.000	86	28.000
III	Natural spawning	146.800	90	102.900

In artificial propagation, the protective egg jelly is removed using the carbamide method and the eggs are incubated in Weis jars. In natural spawning, eggs are incubated in composite tanks with the gentle influence of a stable water temperature of 29 to 30^{0}C. Embryo development time is 20 to 22 hours after the eggs are fertilised. The FFRC (1996) reported that fish hatched 24 to 32 hours after fertilisation. This difference in embryo development time between the 2 studies might be due to water temperature. The temperature of the incubation water in this study (29-30^{0}C) was higher than that in the FFRC study

The results showed that the fertilisation, hatching and survival rates of 3 day–old fries in natural spawning conditions is higher than the rate for artificial spawning (see table 14 and 15).

Nursing fry to juvenile (3 to 14 days old)

At water temperatures of 29.5 to 30^{0}C, 60 hours after hatching, larvae start feeding on small Moina despite their still having a yolk sac. During the beginning of spawning time II, fries were nursed in plastic lined tanks and composite tanks and fed on Moina. Results showed that their survival rate was low (2% and 5% respectively). This might be due to the larger size of the Moina compared to the fry and continuous aeration which may have caused bubble disease. Results from fish nursed from 3 to 14 days are shown in table 16

Table 16: Survival rate of 14 day-old fish (Third spawning time)

Variable	Lot	Nursing density (Fish/liter)	Survival rate (%)	Number of 14 day- old fish
I	1	8	80	960
	2	10	82	1,230
	3	12	78	1,404
II	1	8	92	1,104
	2	10	90	1,350
	3	12	89	1,602

In this experiment, the survival rate of fish increased significantly because they were fed on newly hatched Moina. Fish fed on Artemia also had high survival rates because of the small size of the Artemia. All 5 day-old fish were then fed on Tubifex until they reached 14 days. Fish were weighed and measured at the end of the experiment.

Table 17: Mean length and mean weight of fry at 14 days.

Days old	Variable I						Variable II					
	Lot 1		Lot 2		Lot 3		Lot 1		Lot 2		Lot 3	
	L	P	L	P	L	P	L	P	L	P	L	P
	mm	mg	mm	mg	mm	mg	mm	mg	mm	mg	mm	mg
3	5.5		5.5		5.5		5.5		5.5		5.5	
14	17.3	56.3	16.4	45.5	17.7	58	17.1	55.6	18.7	67.5	17.7	45.3

Note: L: length, P weight

Three day-old fries have lengths of 16.4 – 17.7 mm after 2 weeks, the length and weight of fish in 3 lots was not significantly different ($P > 0.05$). Therefore, a nursing density of 12 fish/L gives the best results. Moreover, the length and weight of fish in two variables (fed on *Moina & Artermia*) are also not significantly different ($P > 0.05$).

However, the growth divergence rates between the two variables are different. In variable I, the growth divergence rate for 14 day-old fish is 15 to 20%, variable II is lower at 5%. The growth divergence of carnivorous fish (walking catfish, green catfish) is decisive for the survival rate of fish in the next stage. Feed size and feed quality are important to Green catfish from the outset.

All 14 day–old fish in the third spawning period were nursed to fingerlings (28 days) and controlled.

D. Conclusion

Green catfish are a potentially important species for aquaculture in the near future because they have high fecundity rates (126,364-142,000 eggs/kg), eat miscellaneous species, can be cultured in high densities, and have a fast growth rate.